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SUBSTITUTE SPECIFICATION

TITLE OF THE INVENTION

INSULATING ARRANGEMENT FOR THE INNER INSULATION OF AN AIRCRAFT

FIELD OF THE INVENTION

The invention relates to an insulating arrangement for the inner insulation of an air vehicle.

BACKGROUND OF THE INVENTION

It is known that the primary insulation located on the structure side for insulation systems presently used in aircraft construction essentially consists of an insulation core material and a film covering or encasing this insulation core material. The core material of the insulation system is protected against water entry with the conventionally utilized films. Moreover, the film covering or casing serves to secure the partially bulky or flossy insulation material. Generally, this film casing or covering is dimensioned so that it contributes the lowest possible weight to the overall insulation system.

In this context, due to the relatively thin film, water vapor diffuses through the film wall, and penetrates into the film-covered insulation packet. Thereby, the water vapor partially condenses in the insulation packet. Moreover, diffused liquid particles or water droplets repeatedly enter into the insulation packet through unsealed or leaky areas in the insulation packet or in the film covering. Due to the condensation in the insulation packet, the liquid particles or water droplets collect in the insulation material, and this accumulated water may only be removed by additional drying efforts. This also has a very unpleasant effect, namely that the insulation system gains in weight due to the water accumulation and thereby leads to an unnecessary increase of the weight of the aircraft.

SUMMARY OF THE INVENTION

In view of the above, the invention is based on the object, to embody an insulation arrangement of the above mentioned type so that nearly no humid or moist air or other moist gas or water vapor or droplets will penetrate into the film-covered insulation packet and so that any moisture that does accumulate in the insulation packet shall quickly escape without hindrance from the insulation packet.

The above objects have been achieved according to the invention in an insulation packet comprising an insulation material completely surrounded and encased by a film that is selectively permeable to the diffusion of gases such as water vapor

therethrough. Particularly, the film has a different diffusion resistance in an inward diffusion direction through the film in comparison to an outward diffusion direction through the film. Preferably, the film exhibits a higher diffusion resistance coefficient with respect to gas diffusion in the inward diffusion direction from outside of the packet to inside of the packet, and a lower diffusion resistance coefficient for gas diffusion in the outward diffusion direction from inside of the packet to outside of the packet. The gas of interest is especially water vapor.

The above objects have further been achieved according to the invention in a preferred embodiment, in which the above mentioned insulation packet is provided as an improved insulation packet of an insulation arrangement of an air vehicle, including an outer skin, an inner trim component that is spaced apart from the outer skin with an interspace therebetween, and the insulation packet arranged in the interspace. Preferably, the film of the insulation packet includes a first film section on an outer side of the packet facing toward the outer skin and a second film section on an inner side of the packet facing toward the inner trim component. The first film section provides a relatively lower diffusion resistance in a direction out of the packet toward the outer skin, while the second film section provides a relatively higher diffusion resistance in a direction from the inner trim component into the packet.

As a result of the above characteristic features of the invention, the film hinders the penetration of water vapor into the insulation packet, and preferentially allows water vapor inside the packet to diffuse out of the packet through the film.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be clearly understood, it will now be described in greater detail in connection with example embodiments, with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic sectional view of a conventional insulation arrangement in a wall of an aircraft, including an insulation packet arranged in an interspace between an inner trim component and an outer skin;

Fig. 2 is a schematic sectional view similar to Fig. 1, but showing the inventive insulation arrangement with an improved insulation packet including a selectively gas permeable film covering; and

Fig. 3 is a schematic sectional diagram of a film packet according to the invention, graphically representing the directionally dependent gas diffusion resistance of the film that covers the packet.

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DETAILED DESCRIPTION OF PREFERRED EXAMPLE EMBODIMENTS OF THE INVENTION

Fig. 1 illustrates a conventional insulation arrangement for an aircraft, installed in a known manner within an interspace (hollow space) which is bounded by the inner region A and the structure region B of the aircraft. In practice, the interspace 7 is formed between the metal outer skin 6 (allocated to the structure region B) and an inner trim component 12, for example a plate-like cabin trim panel arranged at a spacing from the outer skin 6. In this context, the inner trim component 12 largely follows the curvature of the outer skin 6, whereby a straight linear contour of both of these components is selected for simplicity in Figs. 1 and 2. The inner trim component 12 is provided with machined-in slits or other holes or penetrations at certain locations, through which cabin air 9, which is generally relatively warm and has a relatively high moisture or humidity content, penetrates into the interspace 7. The actual insulation arrangement comprises an insulation packet 1 and a conventional film covering i.e. film 4 of synthetic plastic, which encases or covers the above mentioned bulky or flossy insulation material, or insulation material consisting of a foam, of the insulation packet 1, for the purpose of securing the same. An air gap s is formed between the insulation packet 1 and the outer skin 6.

The conventional insulation arrangement of known insulation systems, uses films 4 that largely prevent the entry of liquid

water (entry of water, moist or humid air or other moisture), yet are not water vapor tight due to their low density or tightness or due to the low diffusion resistance coefficient of the film covering. This is especially disadvantageous on the film region or area directed toward the warmer cabin side of the insulation arrangement. The forward penetration of the relatively warm cabin air 9 through the slits and cut-out notches of the inner trim component 12 (cabin trim paneling) continues to the surface of the film 4. Thus, the air 9 loaded with a high moisture or humidity content can get into the insulation packet 1 through the film wall by an expected water vapor diffusion process.

During the cruise flight phase of the aircraft, a strong cooling of the outer skin 6 to approximately -50°C will occur. Thus, it cannot be avoided, that the moisture contained in the water vapor condenses due to falling below the dew point. The result will be a collecting or accumulating of moisture or ice in the insulation packet 1. During the landing and ground operation phase of the aircraft, the temperature of the outer skin 6 will increase. During this phase, the ice in the insulation packet 1 will correspondingly melt to become water in the insulation packet 1. The water will, however, only be able to leave or escape from the insulation packet 1 through larger (microporous) openings (not shown) in the film wall. It is disadvantageous, that therefore the possibility also exists, that water will once again enter into the insulation packet 1 through these film openings.

The release of water through the film wall in the form of water vapor is, however, only possible during a limited time, since the ground time of a commercial transport aircraft will generally be kept relatively short, and the conventional film 4 is not laid out for a more rapid release of water vapor out of the insulation packet 1. The above mentioned diffusion process will lead to an undesired accumulation of condensate water in the known insulation packets 1 that are encased or covered with a conventional film 4.

In the following, example embodiments of the invention will be described in greater detail with reference to Figs. 2 and 3. For the sake of a better understanding, the insulation arrangement according to Fig. 3 will first be considered in greater detail. An insulation structure or arrangement is contemplated, which is made up of an insulation packet 1 and a film 5, which completely encases or covers the insulation packet 1, according to the example of Fig. 1. The installed arrangement of this insulation structure, which will similarly correspond to the arrangement according to Fig. 1, has been omitted from this schematic illustration. According to the two Figs. 2 and 3, generally a film arrangement is contemplated, which is made up of a single film 5 encasing the insulation packet 1 or of two films or film sections 2, 3 encasing the insulation packet 1 which two film sections are integrated into a single film 5 (intended according to the example of Fig. 3). Both film arrangements are generally realized with a gas-permeable film material having a different diffusion resistance characteristic dependent upon the diffusion

direction of the total structure from the humid or damp inner space 7 to the cold outer skin 6.

With reference to Fig. 3, the differential diffusion resistance characteristic of the film 5 is achieved with a film material which provides a high diffusion resistance coefficient with respect to inward diffusion through the film from the film outer wall surface to the film inner wall surface, and provides a low diffusion resistance coefficient in the opposite diffusion direction (namely, from the film inner wall surface to the film outer wall surface).

This above described film structure 5 is worth consideration, because one may therewith enclose or cover the outer surface area of the insulation packet 1 on all side areas with a single film 5 consisting of the same common film material, from the point of view of a rational fabrication of the insulation arrangement. This film 5 will function in such a manner, whereby the diffusion resistance coefficient is large in a direction toward the internally located insulation packet 1 which is entirely covered or encased by the film 5. In other words, no water vapor can penetrate inwardly entirely to the insulation packet 1. The film 5 acts as a moisture blocker, i.e. a vapor barrier. In the opposite direction, the film 5, however, has a different diffusion resistance coefficient, which is as small as possible, so that in the given case, the water accumulated inside the inwardly located insulation packet 1 can easily diffuse out of the insulation packet 1 in the form of water vapor.

Returning to Fig. 2, as mentioned, a film casing or covering is utilized, which is assembled or made up of two film sections or films 2, 3 of different types of materials. The two films 2, 3 are fixedly and seamlessly joined with each other along their film edges, so that one obtains a film casing or cover according to the example of the Fig. 3. Furthermore, it is a prerequisite, as already explained with regard to Fig. 1, that the insulation arrangement according to the Fig.2, with the film casing or cover made up of first and second films 2, 3, is likewise arranged within the mentioned interspace enclosed by the inner trim component 12 (cabin trim paneling) and the metal outer skin 6 of the aircraft.

Thereby the insulation packet 1, which is fully covered or encased by the film 5 made up of the two films 2, 3, will not completely line the interspace. Thereby the insulation arrangement will always be surrounded by a certain hollow air space, due to an intended supply of conditioned air 11 as will be described below.

This film casing 5 that is fused at the film edges of two films 2, 3 completely encloses the insulation packet 1 and lies thereon in such a manner so that the film surface of a first film 2 predominantly is arranged lying on the stringer 8. The film surface of a second film 3 predominantly is positioned opposite the surface of the inner trim component 12 facing toward the inner space 7. The above descriptions say that the films are "predominantly" arranged as stated because certain edge regions

or portions of the surface, that are limited to the section(s) of the fusion of both films 2, 3, are oriented in the direction of the lengthwise extension of the inner trim component 12 or of the stringer 8, and from there the above mentioned conditioned air 11 will also enter into the mentioned inner space 7.

Thereby the first film 2 will lie on the extended surface area of the stringer 8, thus in the selected example, not lying on the inner trim component 12. Since the second film 3 is located free in the inner region 7 and not lying on the inner trim component 12, the second film 3 will be surrounded most extensively by the conditioned air 11 flowing through the inner region 7.

It is also mentioned at this point, that several spacer members are arranged between the outer skin 6 and the insulation packet 1, or between the stringer edge of the stringer 8 and the insulation packet 1. Hereby an air gap s is formed.

The first film 2 consists of a film material that provides a low diffusion resistance coefficient in the diffusion direction of the gas diffusing through the film wall from the film inner wall surface to the film outer wall surface. The term gas is understood to mean, as mentioned previously, relatively warm air, which is loaded with high moisture or humidity, which flows through the slits and openings of the inner trim component 12 into the inner region 7.

The second film 3 consists of a film material that provides a high diffusion resistance coefficient in the diffusion direction of the gas diffusing through the film wall from the film outer wall surface to the film inner wall surface.

According to all embodiments of the described insulation arrangement, the film-encased insulation packet 1 comprises an insulation material consisting of polyphenylene sulfide (PPS). The latter is covered or encased by the single film 5 embodied as a synthetic plastic film according to Fig. 3, or by the film arrangement consisting of two different types of films 2, 3 which are combined together to form thereof a single combined film 5 according to Fig. 2. Thereby the film material(s) of the film 5 provide(s) a differential diffusion resistance coefficient, depending on the direction of the diffusion occurring through the film wall, as described previously. Their spatial arrangement within the inner region or interspace 7 is adapted, at the location of their contact surface, to the surface contour of the surface of the stringer 8 (oriented toward the inner trim component 12) and to the surface contour of the inner surface of the outer skin 6 respectively.

Summarizing the above discussion, the different films 2, 3, 5 according to Figs. 2 and 3 consist of different types of film materials, so as to prevent an accumulation of condensate water in the insulation packet 1 encased by the film. The second film 3 according to Fig. 2 facing toward the inner region A comprises a film material that provides a high diffusion resistance

coefficient in the vapor diffusion direction from the film outer wall surface to the film inner wall surface. That has the advantage that the air that is loaded with a relatively high moisture or humidity, which flows in through slits and openings from the inner region A (for example from the passenger cabin of an aircraft) into the interspace 7, cannot diffuse directly into the primary insulation. At the area of the insulation arrangement oriented toward the outer skin 6 as a component of the aircraft fuselage structure, the first film 2 according to Fig. 2 is open to diffusion and comprises a low diffusion resistance coefficient in the vapor diffusion direction from the film inner wall surface to the film outer wall surface.

The above construction provides the advantage, that liquid water, which has accumulated by condensation in the insulation packet 1, can escape from the insulation packet 1 as water vapor in a relatively unhindered manner and therewith quickly, primarily while the aircraft is on the ground at a warm temperature. Thereby the insulation packet 1 is dried. For this purpose it is a prerequisite that a sufficient air gap s exists between the outer skin 6 and the first film 2. The stringer 8, on which lies the primary insulation, thereby functions as a spacer member relative to the outer skin 6. Additional holder elements will serve to maintain, or to enlarge if necessary, the air gap region 10 between the outer skin 6 and the insulation arrangement, i.e. the film-encased insulation packet 1.

Thus, in comparison to the conventional aircraft insulation, two essential effects are achieved by the invention:

a) The water vapor, which can come from the inner region A (originating from the passenger cabin) into the interspace or inner region 7, is prevented from penetrating, i.e. diffusing into the insulation packet 1 by the second film 3 functioning as a vapor barrier.

b) The liquid water, which nonetheless collects in the insulation packet 1, may, for example, leave the insulation packet 1 in the form of water vapor through the diffusionally open first film 2, during the warm ground phase of an aircraft. Thereby a drying of the primary insulation is supported, and therewith the accumulation of condensate water in the insulation system is prevented.

Both embodiments of the presented insulation arrangement according to Figs. 2 and 3 provide the advantage of achieving an additional drying effect even during cruise flight of the aircraft with conditioned air, which is additionally supplied to the affected insulation arrangement by means of an active air conditioning device. This is especially because the film construction according to Fig. 3 will ensure that the insulation packet 1 can be dried out by the above discussed selective outward diffusion. Overall, the following advantages are achieved with the presented insulation constructions:

a) Less water vapor will enter into the insulation packet 1, so that also less condensation takes place in the insulation packet 1.

b) Condensate water, which has once collected in the insulation packet 1, can again escape from the insulation in the form of water vapor.

c) The insulation packet 1 can more easily be dried after all of the above.

d) Condensate water will no longer accumulate in the insulation packet 1.

e) Because less water is present in the insulation, the operating life of the insulation arrangement or system is increased.

f) Corresponding weight is saved in the air vehicle e.g. aircraft, whereby the flight capacity is increased.

g) The suggested measures may be carried out without special effort. That applies also to retrofitting air vehicles that are already in service.

h) If, nonetheless, a drying system is provided and used in the air vehicle, for drying the structure, then the described insulation arrangement according to Figs. 2 and 3 may be installed to achieve an enhanced drying effectiveness.